IMPROVEMENT OF MACHINABILITY AND SURFACE INTEGRITY DURING ELECTRO DISCHARGE MACHINING OF INCONEL 718 USING NANO POWDER SUSPENSION DIELECTRIC

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“This research is dedicated to my family especially to my mother, Halijah Samat and my late father, Ahmad Man, and to my beloved wife, Salbiah Omar and my kids, Mirza and Amani.”

Thank you for the support, encouragement and prayer.

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ABSTRACT

Inconel 718 is one of the most difficult to cut material due to its, high hardness, high toughness, and poor thermal conductivity results in heat concentrated in the cutting zone, making it ineffective to be processed through conventional machining. So usually, an electrical discharge machining (EDM) is chosen in order to overcome such limitations. However, EDM is known as a slow machining process. Thus, by employing powder suspension in the dielectric fluid it is believe to enhance the machining efficiency. To achieve high performance in EDM for this research, higher Peak current, I_p up to 40A, Pulse duration, t_{on} up to 400µs and Powder concentration, C_p up to 4g/l were selected as the main parameters. Copper (Cu) and Copper tungsten (CuW) were used as an electrode. Their influence on the machinabilities of the material removal rate (MRR), electrode wear rate (EWR), and surface roughness (R_a) were experimentally investigated. Some aspect of surface integrity, such as recast layer (R_L) and microhardness (MH) were also evaluated. The circulating dielectric system called High Performance EDM (HPEDM) was used when conducting the experiment incorporating powder suspension dielectric. The results have shown that, at a highest I_p=40A and the lowest t_{on}=200µs with C_p=4g/l yields the highest MRR for both Cu and CuW electrodes. The improvement is about 32% and 50% for both electrodes when compared without powder concentration at the same parameter settings. Meanwhile, machining by using Cu electrode at I_p = 40A, t_{on} = 400µs and C_p = 4 g/l yields the lowest EWR respectively. For the CuW electrode, lowest value of EWR was obtained at I_p=20A, t_{on}=400µs and C_p=0g/l. The lowest R_a when EDM machining by using Cu and CuW achieved at I_p=20A, C_p=0g/l and t_{on}=400µs and 200µs, respectively. In the case of surface integrity, both electrode shows almost similar trend. The R_L thickness for both electrodes were increased with an increase of I_p, t_{on} and C_p. The MH on the R_L is much higher when compared to the base material. In the case of machinability, Cu electrode is the best option in EDM machining of Inconel 718.

ABSTRAK

Inconel 718 merupakan salah satu bahan yang paling sukar untuk dipotong kerana, mempunyai kekerasan dan keliatan yang tinggi, serta sifat pengaliran haba yang rendah menyebabkan haba tertumpu di zon pemotongan, menjadikannya tidak begitu efektif untuk diproses melalui pemesinan konvensional. Jadi, mesin discaj elektrik (EDM) dipilih bagi mengatasi kekurangan tersebut. Namun, EDM dikenali sebagai proses pemesinan yang perlahan. Oleh itu, penggunaan penggantungan serbuk dalam dielektrik dipercayai mampu untuk meningkatkan kecekapan pemesinan. Untuk mencapai prestasi tinggi dalam pemesinan EDM bagi kajian ini, Arus puncak (I_p) yang tinggi sehingga 40A, Tempoh denyutan (t_{on}) sehingga 400µs dan Kepekatan serbuk (C_p) sehingga 4g/l telah dipilih sebagai parameter utama. Tembaga (Cu) dan Tembaga tungsten (CuW) digunakan sebagai elektrod. Kesan parameter-parameter tersebut terhadap kebolehmesinan melalui kadar pembuangan bahan (MRR), kadar kehausan elektrod (EWR), dan kekasaran permukaan (R_a) dikaji. Beberapa aspek integriti permukaan seperti lapisan putih (R_L), dan kekerasan mikro (MH) bahan kerja yang telah dimesin juga dinilai. Sistem aliran dielektrik yang dikenali sebagai *High Performance EDM* (HPEDM) digunakan untuk eksperimen yang melibatkan campuran serbuk. Keputusan menunjukkan bahawa pada I_p tertinggi 40A dan t_{on} paling rendah 200µs serta C_p tertinggi 4g/l menghasilkan MRR tertinggi untuk elektrod Cu dan CuW. Peningkatan kira-kira 32% dan 50% untuk setiap elektrod berbanding tanpa kepekatan serbuk pada tetapan parameter yang sama. Sementara itu, pemesinan dengan menggunakan elektrod Cu pada I_p=40A, t_{on}=400µs dan C_p=4 g/l menghasilkan EWR yang paling rendah. Manakala nilai terendah EWR untuk elektrod CuW direkodkan pada I_p=20A, t_{on}=400µs dan C_p=0g/l. R_a terendah apabila melakukan pemesinan EDM dengan menggunakan Cu dan CuW masing-masing dicapai pada I_p=20A, C_p=0g/l dan t_{on}=400µs dan 200µs. Secara keseluruhannya, ketebalan R_L didapati meningkat dengan peningkatan I_p, t_{on} dan C_p. MH pada R_L jauh lebih tinggi berbanding dengan material utama. Dari segi kebolehmesinan, elektrode Cu adalah pilihan terbaik untuk pemesinan EDM bagi Inconel 718.

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concentration (C_p) [(a) C_p=0g/l, (b) C_p=2g/l and (c) C_p=4g/l]

LIST OF ABBREVIATIONS AND SYMBOLS

Al	-	Aluminium
C_p	-	Powder concentration
Cu	-	Copper
CuW	-	Copper Tungsten
EDM	-	Electro discharge machining
EWR	-	Electrode wear rate
MH		Micro-hardness
HAZ	-	Heat affected zone
HPEDM		High performance electrical discharge machining
HRC	-	Rockwell hardness unit
HV		Vickers hardness unit
I_p	-	Peak current
MRR	-	Material removal rate
OM		Optical microscope
PLC	-	Programmable Logic Controller
PM	-	Powder Metallurgy
PSEDM	-	Powder suspension electrical discharge machining
R_a	-	Surface roughness
R_L	-	Recast layer
SA	-	Surface area
SEM	-	Scanning electron microscopy
SI	-	Surface integrity
SiC	-	Silicon Carbide
t_m	-	Machining times

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